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Fruit Pests and Their Control

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BULLETIN NO. 393

Fruit Pests and Their Control

By P. O. RITCHER, W. D. VALLEAU and W. W. MAGILL

The purpose of this bulletin is to assist the fruit grower, whether he has one tree or many hundreds, by making available the latest information on Kentucky fruit pests and their control. Much of this information was obtained thru research work carried on for the past fifteen years by various members of the Experiment Station staff and is not available elsewhere. Other facts were obtained from records kept by orchardists of the state.

TYPES OF PESTS

Insects that attack fruit may be divided into two classes: chewing insects and sucking insects. Chewing insects, such as curculio, caterpillars, and the larvæ of the codling moth and oriental fruit moth, eat fruit or foliage or both, and can be destroyed by poisons placed on their food. For instance, if lead arsenate is sprayed on apples, the larvæ of the codling moth eat it in burrowing into the apple and are killed. Sucking insects, such as aphids (plant lice), leafhoppers and San Jose scale, pierce the surface tissues with needle-like mouth parts and draw their food from beneath; thus they escape a poison placed on the surface. Therefore, for sucking insects it is necessary to apply a poison that kills by coming in contact with the insect. Nicotine, used in spray or dust, is such a contact poison for aphids and leafhoppers. Oil emulsion destroys scale insects by contact.

Some diseases are caused by minute forms of plant life which live parasitically on the fruit, foliage, or other parts of the plant. Apple scab and brown rot of peach are examples. The organisms

usually penetrate the plant tissues so it is often impossible to destroy them by either spraying or dusting, after infection has occurred. Plant diseases of this type may be prevented by spraying. For example, apple trees are sprayed periodically with lime-sulfur solution from the time the earliest buds begin to open until after blossoming, to protect against apple scab.

SUCCESSFUL SPRAYING

The success or failure of any spray program rests with the individual grower. The programs suggested here are general in nature and must be adapted by each grower to fit his particular section of the state, the particular season, and his particular insect and plant disease problems. The home grower has neither the time nor equipment for applying more than a few sprays. The large commercial grower, on the other hand, often finds it necessary to add sprays to the schedule suggested.

Three things are essential in successful spraying: correct timing, use of right materials, and thoroness of application. Failure in any one of these may result in poor control. Correct timing involves fitting the schedule to the pests to be controlled. The period during which the tree or pest is in the proper stage for any one spray is usually very short, rarely exceeding three days; therefore, materials, labor and equipment must be ready and adequate. Too many growers have lost a crop because the spray rig broke down at a critical time.

The number of spray materials which have become standard is small. Their development is the result of much labor and money spent on research by state and federal agencies and commercial concerns. They have been tested over a period of years under all types of conditions in all sections of the country and their merit is a matter of record. New materials are constantly being offered to growers, often accompanied by extravagant claims. Until these products are thoroly tested, growers will do well to continue using the old materials.

Many growers use the right spray materials at the right time but still get poor control. Usually this is due to poor coverage. To effect good control of chewing insects all fruit and foli-

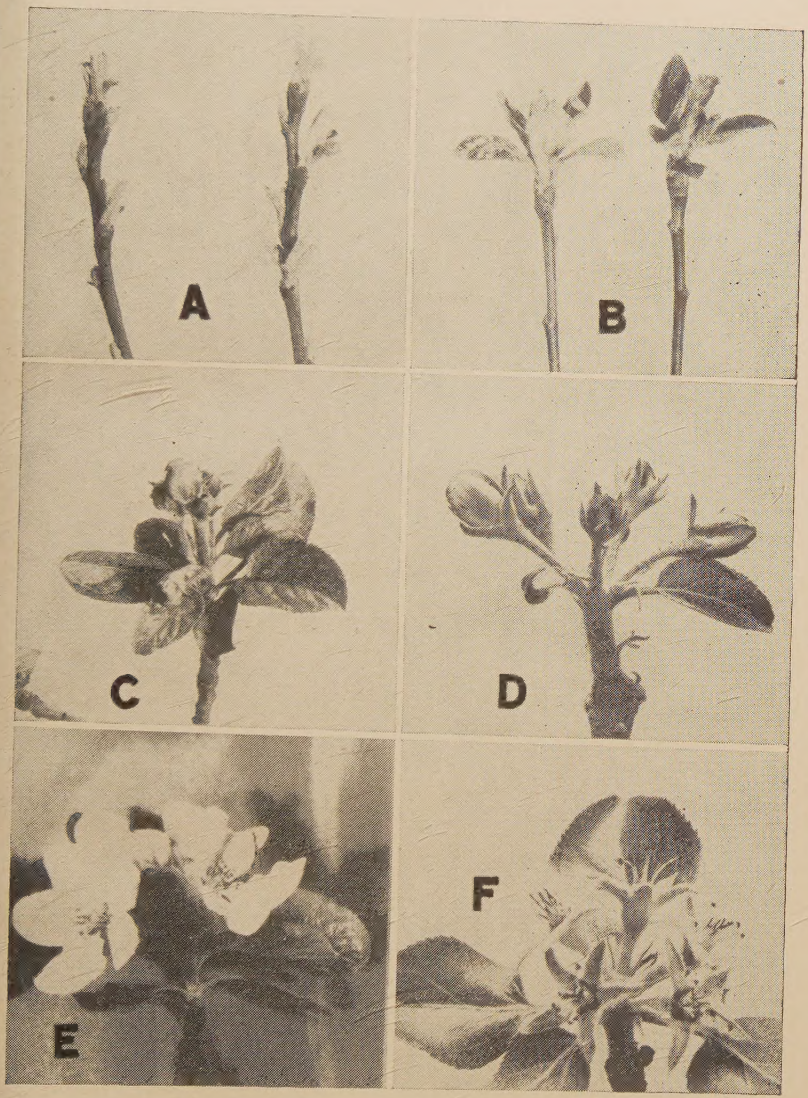

Figure 1. Stages in development of the apple blossom. (a) Green tip, (b) early closed cluster, (c) closed cluster, (d) open cluster (pink), (e) full bloom, (f) calyx.

APPLE SPRAY SCHEDULE*

Spray	Time	Spray Mixtures	For
**1. Dormant	When trees are dormant	Petroleum oil emulsion 2 percent or Liquid lime sulfur 1 to 8 or Dry lime sulfur 30 lbs. in 100 gals. of water	San Jose scale
2. Green tip	When green tips of leaves are exposed, Fig. 1a.	Liquid lime sulfur 2½ gals. Water to make 100 gals.	Scab
*3. Prepink	Before cluster buds separate, Fig. 1b-c.	Liquid lime sulfur 2½ gals. Water to make 100 gals.	Scab
**4. Pink	Fruit buds pink, clusters separated, Fig. 1d.	Liquid lime sulfur 2½ gals. Water to make 100 gals.	Scab
5. Full bloom	One-third of bloom open.	Copper sulfate 2 lbs. Hydrated lime 6 lbs. Water to make 100 gals.	Blossom blight on susceptible varieties, also scab
**6. Calyx	When petals are three-fourths off, Fig. 1f.	Lead arsenate 3 lbs. Lime sulfur 2 gals. Hydrated lime 3 lbs. Water to make 100 gals.	Codling moth worms, scab
7. First cover	Seven days after calyx spray	Lead arsenate 4 lbs. Hydrated lime 4 lbs. Water to make 100 gals.	Codling moth worms, scab
*8. Second cover	Two weeks after calyx spray	Lead arsenate 4 lbs. Hydrated lime 4 lbs. Lime sulfur 1 gal. or Wettable sulfur 8 lbs. or Bordeaux 6-8-100 Water to make 100 gals.	Codling moth worms. Use Bordeaux for sooty blotch, blotch-susceptible varieties and King David
9. Third cover	Three weeks after calyx	Lead arsenate 4 lbs. Hydrated lime 4 lbs. Soybean flour ¼ lb. Water to make 100 gals.	Codling moth worms

*10. Fourth cover	Four weeks after calyx	Lead arsenate 4 lbs. Hydrated lime 4 lbs. Soybean flour ¼ lb. Water to make 100 gals.	Codling moth worms. Use 4–6–100 Bordeaux for sooty blotch, blotch-susceptible varieties and King David
11. Fifth cover	Ten days after fourth cover	Lead arsenate 3 lbs. Hydrated lime 3 lbs. Soybean flour ¼ lb. Water to make 100 gals.	Add 4–6–100 Bordeaux for blotch and bitter rot. Omit lead arsenate and soybean flour if codling moth not serious
*12. First summer	See notes for timing (next page)	Lead arsenate 3 lbs. Bordeaux 8–10–100	Second generation codling moth worms, bitter rot
13. Second summer	Ten days-two weeks later	Lead arsenate 3 lbs. Hydrated lime 3 lbs. Water to make 100 gals.	Second generation codling moth worms. Omit lime and add 4–6–100 Bordeaux if bitter rot injurious in past years
14. Third summer	Ten days-two weeks later	Lead arsenate 3 lbs. Hydrated lime 3 lbs. Water to make 100 gals.	Second generation codling moth worms. Omit lime and add 4–6–100 Bordeaux if bitter rot injurious in past years

* To assist the home or small orchardist who does not require or is not able to put on a full spray schedule, the important sprays are starred.

** The most important sprays are starred twice and are often adequate. Most commercial orchards need all starred sprays and in areas of severe codling-moth infestation, such as Paducah and Henderson, the complete schedule **may be needed.**

age must be covered with the poison coat. To control sucking insects, spraying must be so thoro that every insect is covered. Without adequate equipment no grower can get thoro coverage. In the commercial orchard, trained labor is essential.

NOTES ON THE APPLE SPRAY SCHEDULE

The apple spray schedule as given in this bulletin is for late-maturing varieties of apples, such as Winesap, Stayman, Delicious, Rome, Grimes, and Ben Davis. To avoid excessive lead and arsenic residues on the fruit, more than two cover sprays containing lead arsenate should never be applied to early varieties, such as Yellow Transparent, Henry Clay, Liveland Raspberry and Early Harvest. Where codling moth is severe, additional cover sprays of fixed nicotine or fixed nicotine plus summer oil are recommended for use on early varieties.

Dormant Spray. This spray should never be omitted. When scale is moderate to heavy, a three percent petroleum oil emulsion should be used instead of two percent. To combat rosy aphis, combine a two and one-half percent tar-oil emulsion with the petroleum oil emulsion or use one of the commercial dormant sprays containing materials for the control of both scale and aphis. These materials should be obtained from a reliable company and used according to the manufacturer's directions. Liquid lime sulfur is inferior to oil emulsion for scale control, and it does not control rosy aphis. Liquid lime sulfur is unpleasant to use because of its caustic properties. Dry lime sulfur is recommended for use by the small grower who cannot get oil emulsion.

Calyx Spray. The purpose of the calyx spray, as far as codling moth is concerned, is to fill the calyx cup of each future apple with poison. When the calyx lobes close, this poison is locked up ready to kill any worms that may try to enter the calyx end of the apple later in the season.

Cover Sprays. The first cover spray is of value in orchards where codling moth is a serious problem and growers desire to build up a heavy spray deposit ahead of worm attack. This spray is also recommended for orchards in eastern Kentucky where curculio is a factor.

Growers who plan to use the intensive program of five first-brood cover sprays (sprays numbers 7 to 11) will find that the addition of some adhesive, such as soybean flour, aids in building up smoother and heavier deposits. Soybean flour should be omitted in the first cover spray.

Three summer sprays for second-brood codling moth are suggested for use only where codling moth infestation is heavy and where grow-

ers are prepared to wash their fruit. If excellent codling moth control has been secured in problem orchards by the intensive application of first-brood cover sprays, it may be permissible to omit the lead arsenate in the summer sprays or omit the sprays entirely if bitter rot is not a problem.

Timing Summer Sprays. In the Paducah section, the first summer spray for second-generation codling moth worms should be applied during the last week in June. In the vicinity of Henderson and Bowling Green, the first summer spray should be applied during the three or four days after July 4, and at Louisville and in eastern Kentucky, about July 12. These dates are good only for average years and growers should consult their county agents.

Topping and Spot Spraying. After rains or in orchards where codling moth infestation is heavy, growers can protect their fruit by "topping". Topping is spraying only in the tops and top centers of the trees where the spray material is most subject to weathering. Often topping can be done to good advantage to protect against late first-brood worm attack. Where codling moth is heavy only in small areas such as around packing sheds, growers using only one or two generally-applied cover sprays, may apply additional sprays as "spot sprays".

Supplementary Control Measures. Good orchard management helps produce cleaner fruit. These things are important: (1) Remove all apples from the orchard as soon as picked. (2) Keep the orchard free of all debris. (3) Remove neglected apple or plum trees in the neighborhood. (4) Fertilize and prune the trees and thin the apples to produce larger fruits. (5) In thinning, break all clusters. (6) Thin and destroy fruit when most wormy, in June and again in late July or early August.

PESTS OF THE APPLE

Scale. San Jose scale injures the fruit and bark of apple, peach, and plum trees. It belongs to a peculiar group of sucking insects called scales because of the scale that covers their backs. San Jose scales are minute, round or oval, flattened bodies which appear as a grayish scurf on the bark of trees, when present in large numbers (figure 2). On fruit and young wood, the insects form small, red or reddish-yellow, circular spots.

Young scales move freely about over the tree and are called "crawlers". They soon settle down and in a few days a scale is formed over each insect. Scales injure trees by extracting plant juices with their slender beaks. This at first only checks the

trees' growth but with the rapid increase of the insects, branches and even trees are quickly killed.

Other kinds of scale often found injuring apple trees are scurfy scale, oyster-shell scale, and the lecanium scale.

CONTROL. Formerly, liquid lime sulfur was the standard remedy for scale. In recent years, oil emulsion, either home-made or commercial, have given more effective control. Oil

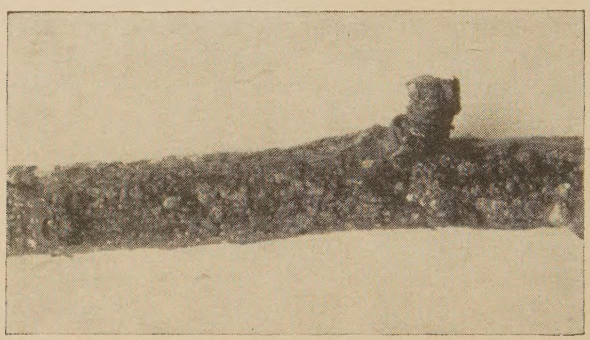

Figure 2. San Jose scale on apple limb.

emulsion is cheaper than lime sulfur, much less caustic on the face and hands, easier to apply thoroly, and is effective against red spider eggs, tree hoppers and leaf rollers. Each grower should go over his trees to see how much scale is present. A three-percent oil emulsion is necessary for heavy infestation. Thoroness of application is essential in scale control.

Codling Moth. This insect is the most important apple pest which the Kentucky fruit grower has to fight. Altho the number of wormy fruits varies greatly from year to year and orchard to orchard, there is no year in which codling moth does not present a serious problem in some part of the state. In some orchards the number of wormy fruits at harvest is less than five percent. In other orchards, as in 1938, when there was a light crop, as many as 30 worm entrances can be found in a single apple (figure 3).

Codling moth worms injure apples in two ways. They either make wormy apples or apples with stings. Wormy apples

fail to grow to normal size, fall before ripening, or ripen too soon and make only culls. Stings on apples are caused by worms that burrowed thru the skin and soon died from the effects of eating poison spray or from natural causes. Stung apples are not allowed in a first-grade pack.

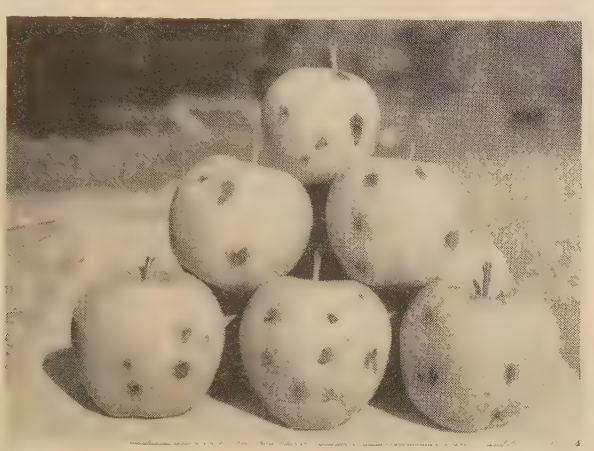

Figure 3. Golden Delicious apples damaged by codling moth. Note number of entrances.

Codling moth spends the winter as a full-grown worm, enclosed in a silk-like cocoon (figure 4b). Most worms overwinter on the tree and many can be found under bark on the trunk and large limbs of the apple trees. Other worms select punky wood, knot holes, split branches, crotches and pruning stubs for overwintering places. A few worms overwinter on the ground on exposed apple roots or among dried fruits and other trash. Often, an enormous number of worms overwinters in and about packing sheds.

In April, the overwintering codling moth worms begin changing to the pupa stage, in which the change to the adult codling moth takes place. Adult moths (figure 4d) start emerging in May. They become active at dusk if the temperature is 60° or above, fly about and soon begin laying their small, white, pancake-shaped eggs (figure 4a). The eggs are laid singly on

either side of the leaves or on twigs or fruits. Eggs laid by the first moths hatch in 10 to 14 days, depending on the prevailing temperature, and give rise to first-brood worms which soon find their way to the small apples. The first worms enter apples about three weeks after petal fall, many entering thru the calyx cups. Later on, many worms bore into the sides of the apples and are called "side worms".

After feeding for a month or more, the first-brood worms chew their way to the surface, leave the fruit and spin cocoons in the same kinds of places where they overwinter. After passing thru the pupa stage (figure 4c), the adult moths emerge and begin laying eggs which give rise to second-brood worms. When full grown, many second-brood worms go into winter quarters. Others pupate and change to adults which give rise to a third brood of worms.

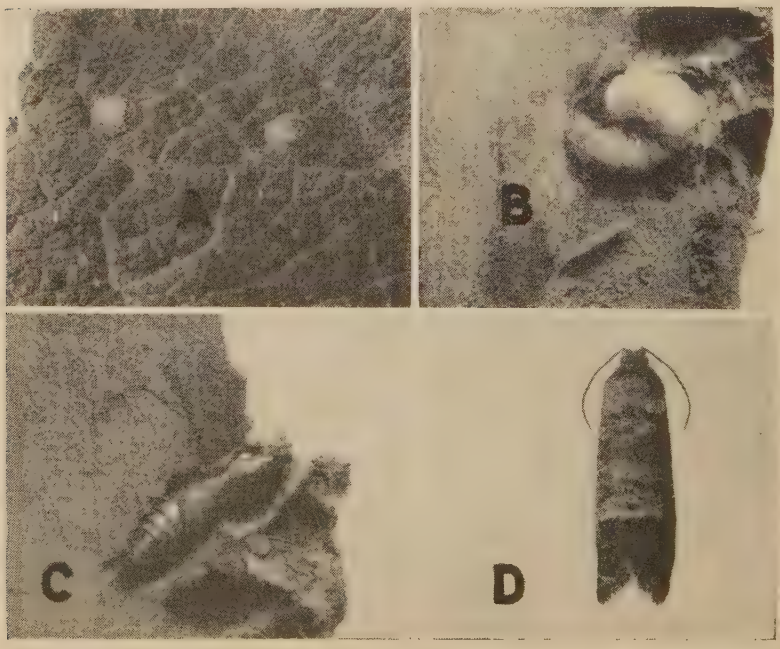

Figure 4. Eggs, full-grown larva, pupa and adult of the codling moth.

Seasonal Observations, 1927–38. Correct timing of codling moth sprays is essential to control. In order that Kentucky apple growers may have available information that will help them plan their spray programs in future years, certain records on codling moth behavior in past years are given in the following paragraphs.*

Pupation of overwintering worms in Kentucky begins between the last week in March and the second week in April, depending upon the advancement of the season. The length of the pupal stage for early pupæ varies from 21 to 28 days. This means that moth emergence can be expected to commence three to four weeks after the beginning of pupation. At Paducah, the earliest record for moth emergence is April 15 (1938). At Lexington, the earliest record is April 26 (1938). Moth emergence usually starts from 6 to 14 days after petal fall. When high temperatures prevail during the month following petal fall, most of the spring moths emerge over a period of only two weeks. Such conditions are ideal for obtaining first-brood control with a minimum number of sprays because of the bunching of first-brood egg hatch. In other years, such as 1938, when the weather turns cool shortly after petal fall, spring moths may emerge over a period of six weeks or longer. This makes good control difficult and means that more than the usual number of cover sprays is needed.

Egg laying by spring-brood moths begins from twelve days to three weeks after petal fall, in Kentucky. Several years' records for Paducah and Henderson show that the first worms enter apples 3 to 4 weeks after petal fall. Full-grown, first-generation worms begin leaving fruits about June 1 at Paducah and Henderson. At Lexington, the first worms are usually full grown by June 12. In Kentucky, almost 100 percent of the first-generation worms soon pupate and give rise to a second and often a third brood of worms. Because of this, first-brood control is extremely important. If growers can get good control of first-

* Many of the records were made by C. O. Eddy and P. O. Ritcher. The 1927 records were made by H. H. Jewett. Other records are furnished by Ted Cooper of Paducah, Frank Street of Henderson, J. W. Fegenbush of Louisville, and other interested fruit growers.

brood worms, they should have no difficulty with later broods. If the first brood is not controlled, then control of later broods is almost impossible.

First-generation moths begin emerging at Paducah and Henderson the second or third week in June. Heavy moth flight usually continues until the middle of July and sometimes a week longer, in these localities. At Lexington, first-generation moths begin to emerge the last of June or the first week in July. In 1936, at Lexington, first-generation moth flight was heavy between July 2 and August 2. In general, hatch of second-brood worms can be expected about ten days after the emergence of first-generation moths and the first second-brood spray should be timed accordingly.

Second-generation worms, when full grown, leave the apples and seek places to spin their cocoons. Many remain as worms over winter. Others soon pupate and give rise to a third brood of worms which attacks apples in late August and September. In 1927, a cold season, no evidence of a third brood was found at Henderson. Third-brood moths usually begin emerging between the last of July and the first week in August. Third-brood worms usually begin entering apples from the first to the second week in August.

Growers will find it helpful to get reports from areas of the state where the season is ahead of their particular area. In most years, events at Henderson, such as first moth emergence, occur from 2 to 5 days later than at Paducah. Louisville events run from 5 to 12 days later than the same events at Paducah. Events at Lexington are from 14 to 18 days behind Paducah. By using these calculations and knowing when some event such as worm hatch began at Paducah, a grower can often estimate when to expect hatch in his own locality.

Control. The control of worms by spraying is outlined in the spray schedule. Certain supplementary control measures such as thinning, removal of debris, and getting rid of neglected apple trees in the neighborhood are suggested in the notes following the spray schedule. The use of bands and screening packing sheds are two supplementary controls which can be used

to good advantage in orchards where codling moth is a serious problem.

Banding. Poison bands are now used extensively in many sections of the country as a supplement to the spray schedule (figures 5 and 6). The bands used are 2- or 4-inch strips of corrugated paper which have been dipped in a bath of beta

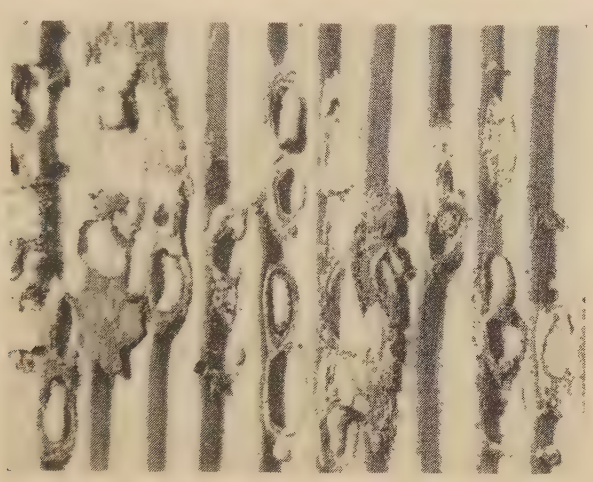

Figure 5. Section of codling moth band showing trapped worms.

naphthol dissolved in oil or gasoline. This treatment renders bands toxic to worms that crawl into them.

Before applying bands, trees must be scraped to get rid of the rough bark that forms the natural hiding place of the codling moth worms. In scraping, one should avoid injuring the live bark and all scrapings should be collected and burned. Satisfactory scraping tools can be made from old hoes, or an old mower blade section fastened to a handle can be used.

In applying bands to trees, a strip of band is wound about the trunk, about two feet from the base, and fastened snugly against the bark with staples or large-headed nails (figure 6). At Paducah, injury to the bark has resulted where nails driven thru the bands were used. Bands should be applied in time to

catch the first worms leaving the apples. At Paducah and Henderson, bands should be in place by June 1. At Lexington, they should be put on before June 10. Since bands lose much of their strength by fall, all bands should be removed some time

Figure 6. Codling moth band in place on apple tree.

during the winter and destroyed. December is a good time to do this. CAUTION.—Bands should never be put on trees with smooth bark.

Screen Packing Sheds. Great numbers of worms often overwinter in packing sheds, in packing crates, baskets, and other hiding places. Careful screening of packing sheds prevents moths from these worms getting back to the orchard the following year.

Plant Lice. Four kinds of plant lice (aphids) are commonly found in Kentucky apple orchards: the rosy aphid,[1]

[1] The species of apple aphis are not always easy to distinguish with the naked eye. Rosy aphis can be identified under a lens by the fact that the newly hatched young have long cornicles on the back of the abdomen (honey tubes) and the green apple aphid and the apple-grain aphids have very short cornicles.

the green apple aphid, the apple-grain aphid and the woolly aphid. The first three species are commonly found on the opening buds in the spring.

The rosy aphid, in certain years like 1938, is a serious pest all over the state. In other years, like 1936, it is of no importance. Rosy aphis attacks the foliage and fruit clusters. The leaves become greatly curled and small apples fail to grow and become knotty and gnarled. Rosy aphis attack seems to prevent normal June drop and the deformed apples tend to hang in clusters on the tree (figure 7). Rosy aphids spend the summer on plantain, returning to the apple trees in the fall, where their eggs are laid.

The green apple aphis lives on the apple tree the year round. Its injury is most severe on nursery stock and young trees. In the orchard this aphis is most common on water sprouts or other succulent growth where it causes severe curling of the leaves.

Figure 7. Apples deformed by rosy aphis.

The apple-grain aphis is usually the most abundant aphis in the spring, on fruiting clusters. It does little damage as it soon leaves the apple and goes to grains and grasses where it spends the summer.

The woolly apple aphis is mainly a pest of young apple trees working on the roots where it causes knotty swellings. Sometimes the woolly aphis is found above ground on apple trees. It almost always works on water sprouts and in wounds or other injuries. The woolly aphis spends part of its life cycle on elm trees where it lives in galls on the leaves.

Control. The rosy aphis is best controlled by a dormant application of coal-tar oil emulsion or petroleum oil emulsion containing dinitrocyclohexyphenol (DNOCHP) (see spray schedule). Rosy aphis can also be controlled with a green-tip (delayed dormant) spray using either (a) 3 percent petroleum oil emulsion plus 1 pint nicotine sulfate to 100 gallons or (b) a 3 percent petroleum oil emulsion plus ½ percent cresylic acid. These sprays also control green apple aphis and apple-grain aphis. When green apple aphis is abundant in summer it may be controlled by adding nicotine sulfate to any spray scheduled for that time or by using a separate spray.

Curculio. The curculio attacking apples in Kentucky is the plum curculio which also attacks peaches and plums. For a discussion of its habits, see the section on peach insects. Curculio is most apt to be injurious to apples in eastern Kentucky orchards. To control this pest, apply the first cover spray 7 to 10 days after calyx spray (see apple spray schedule). Where only a few trees are involved, picking up and destroying all early drops is helpful.

Apple Leaf Skeletonizer. Skeletonizing the leaves in the tops of apple trees is done by a small, striped, greenish or brownish caterpillar, the adult of which is a purplish-brown moth whose front wings are each marked with two silvery-gray bands. It is injurious only where the top branches have not been thoroly sprayed.

Leafhoppers. Several species of small, triangular-shaped insects called leafhoppers are often exceedingly abundant in

Kentucky apple orchards. They pierce the tissues of apple leaves and suck the sap and also speckle the fruit with their excrement and make it unsightly. Since leafhoppers always feed on the undersides of the leaves, their presence may escape notice. When abundant, the leaves lose most of their green color and take on a spotted yellow and white appearance. Jarring any limb causes the pests to fly out in swarms.

When leafhoppers are abundant, special control measures may be necessary. Adult leafhoppers are difficult to kill but the nymphs are easily killed by spraying with nicotine sulfate, either with soap or in combination with any spray of the regular schedule. Nicotine sulfate should be used at the rate of ¾ pint to 100 gallons of spray and the application should be timed by the presence of nearly grown nymphs.

Apple Scab. The apple scab fungus causes several types of injury. On leaves it produces a superficial, olive-greenish spot which frequently ends in death of the affected part or of the whole leaf. Early spring infections on the calyx lobes, or sepals, or flower buds not yet showing pink, may shed spores on the developing fruit, resulting in distorted apples with the characteristic black spots on one side of the blossom end. Infections on the fruit stems during blossoming result in dropping of the blossoms of some varieties. Other varieties, as the Kinnaird, appear to be highly resistant to this type of injury.

Infections following the blooming period cause black spots scattered over the surface of the fruit. The disease develops best in cool weather; comparatively few infections take place in warm weather, altho the spots continue to increase in size with the development of the fruit.

The scab fungus overwinters on leaves infected during the fall. Minute black, spherical fruiting bodies develop during the winter on leaves on the ground. Some spores may be mature at the time the earliest varieties begin to bloom unless this period is preceded by dry weather. If, because of dry weather, spores are not mature when growth commences, some spores may be expected to mature with the first heavy rain and be discharged during the following rain. The spores are shot with some force

into the air when the dead leaves are wet. Thus infection may occur at any time following exposure of green parts if spores are mature and there is sufficient rain to wet the old leaves. Secondary spores are produced in a few days on the new infections and from these the disease may spread as the buds advance. Failure to prevent infection during the prepink stage of blooming appears to have resulted in much scabby fruit, especially on Delicious, and loss of crops in the past in Kentucky.

Prevention. Protection of the early-blooming varieties, as Delicious, with a spray applied soon after the green tips of the flower buds appear, with constant protection thru the blossoming period, appears to be essential for control of scab, especially when rains are frequent. If weather reports indicate continued dry weather during early bloom, spraying may be delayed until rains are indicated, when a spray should be applied immediately. This procedure may not be safe when several days are required to cover the orchard, in which case it is safer to follow a more complete schedule. Weak Bordeaux mixture applied during the blooming period, for blight control, may also assist in preventing infection of the fruit stems. Timeliness with respect to rains, in order to prevent primary infections, appears to be all-important in scab control.

Fire Blight. This bacterial disease of the apple and pear is destructive some years and may then seem to disappear nearly entirely, for a time. The cause of this irregularity is not fully understood. Blossom clusters destroyed by blight, turn black and remain on the tree, in contrast with frost-injured blossoms which are not killed outright and may show no outward sign of injury, but fall after blooming. Twig blight is common, giving the tree the appearance of having been scorched by fire. Susceptible varieties of pears and rapidly growing Transparent apples, as well as some other susceptible varieties, may have whole limbs destroyed by blight. Old Transparent trees are usually free from this type of injury. There appears to be a direct relation between overwintering cankers on pear trees, and to a much less extent on apples, and blossom blight. Complete removal of all dead wood and bark from pear trees in the vicinity

of apple orchards each winter is recommended. Promising results have been obtained in increased set of fruit, in years when blossom blight was abundant, by spraying a weak Bordeaux mixture (1–3–50) directly into the blooms when about ⅓ of the blossoms are open. This spray is recommended where blight is a factor and may aid in scab control, especially when the blooming period is extended.

Blotch affects comparatively few varieties of apples commonly grown in Kentucky. Among the more susceptible are Oldenburg, Maiden Blush, Gano, Ben Davis and Rome Beauty. The blotch fungus attacks the fruit, producing more or less circular, superficial, radiating black spots. These may remain superficial, but on very susceptible varieties the tissues are killed and the spots become sunken and black by picking time. Frequently small, black pimples, the fruiting bodies, develop in the spots. Leaf infections occur, being most prominent on the under side of the mid-vein and on the leaf stem as small, dead areas. Infection at the base of the leaf stem may spread into the twig producing a canker about the bud. These cankers may produce spores for several years. As canker prevention is essential in the control program, spraying for blotch on susceptible varieties must be done each year, crop or no crop. Infection spreads from fruiting bodies on the rough twig cankers, beginning about two weeks after petal fall and continuing for about 6 or 8 weeks. Protection of susceptible varieties is essential during this period. Bordeaux mixture as recommended in the cover sprays for the first-generation codling moth controls blotch and helps in bitter-rot control. For control where blotch is a minor factor, lime sulfur may be used.

Sooty Blotch is a fungus disease of apple which results in a sooty appearance of the skin of the fruit in August or later. It is entirely superficial but injures the appearance of the fruit. The disease is likely to be severe in any orchard which is surrounded by a natural growth of trees and shrubs several of which are hosts of the fungus. In Indiana it was found that Bordeaux mixture added to the second and third cover sprays for first-generation codling moth was effective in control.

Bitter Rot. This disease usually appears during humid, hot periods in the summer and fall, as brown, rotten spots which have a flat surface. Spread by insects such as flies is rapid. Removal and destruction of the first affected fruits and an immediate spray with Bordeaux mixture on the surrounding trees and the destruction of the overwintering fungus (in mummied fruits, fruit stems, cankers) usually located above the first rotten fruits, aids in control. In orchards where the disease rarely occurs a Bordeaux spray applied in the first cover spray for second-generation codling moth in late June or early July goes a long way towards preventing its recurrence. Where it has been injurious during the past 2 or 3 years, Bordeaux mixture should be used in the fourth cover spray for first-generation codling moth and in the three sprays given in the spray schedule for the second-generation codling moth; that is, at two-week intervals beginning about the middle of June and continuing until four sprays have been used.

King David Fruit Spot. The King David variety is affected by a fruit spot (Brook's fruit spot) which makes its appearance in August. Other varieties do not appear to be extensively affected by this disease in Kentucky. The spots are small, irregular, greenish to black in color and after harvest the affected tissue, to a very shallow depth, dies and turns black. The disease is apparently identical with Brook's fruit spot or phoma fruit spot which is injurious to many other varieties farther north. It is claimed that the fungus produces a perfect or wintering stage on dead leaves on the ground, from which the spores are discharged. Infection appears to take place 4 to 6 weeks after petal fall, but the spots do not appear on the fruit until late in the summer. Studies conducted in southern Ohio and elsewhere indicate that best control is obtained by spraying with Bordeaux mixture in the second and third cover sprays for first-generation codling moth.

Black Rot. This fungus sometimes causes a black rot of the blossom end of Stayman and some other varieties of apples about three-fourths grown. This appears to follow arsenic injury. Leafspot due to the same fungus is quite common on

THE PEACH SPRAY SCHEDULE*

Spray	Time	Spray Mixture		For
*1. Dormant	Before buds swell	Tank-mixed oil Bordeaux or Liquid lime sulfur 1 to 8 or Dry lime sulfur 30 lbs. to 100 gals.		Scale and leaf Curl. Apply either in fall or early spring. 6–6–100 Bordeaux is preferred.
2. Shuck fall	When 75% shucks off—2-3 weeks after bloom	Lead arsenate Hydrated lime Zinc sulfate Water	2½ lbs. 2½ lbs. 2 lbs. 100 gals.	Curculio. Omit if no curculio present, or spray in spots for scattered infestations
*3. Ten-day	Month after petal fall or 10 days after shuck fall. This spray should not be postponed	Lead arsenate Hydrated lime Zinc sulfate Wettable sulfur Water	2½ lbs. 2½ lbs. 2 lbs. 6 lbs. 100 gals.	Scab, curculio. If jarring shows no curculio, omit arsenate, lime and zinc.
4. Twenty-four-day	Two weeks later if jarring indicates the need	Lead arsenate Hydrated lime Zinc sulfate Water	2½ lbs. 2½ lbs. 2 lbs. 100 gals.	Curculio. Use as jarring results indicate
*5. First pre-harvest	Three weeks before harvest	Wettable sulfur Water	6 lbs. 100 gals.	Brown rot
*6. Second pre-harvest	Just before harvest	Wettable sulfur Water	6 lbs. 100 gals.	Brown rot

* Growers who do not practice jarring may use the starred sprays as a fixed schedule.

apple trees and usually may be traced directly to a mummied fruit or to a dead twig or branch which will be found to be covered with the fruiting bodies of this fungus. Removal of mummied fruits and dead wood, together with the regular spray program, controls this disease.

NOTES ON THE PEACH SPRAY SCHEDULE

The peach spray schedule is designed to control such important peach pests as San Jose scale, plum curculio, brown rot, and leaf curl. The peach-tree borer is controlled by methods other than spraying and its control is taken up under the discussion of peach pests.

Oil-bordeaux is the preferred dormant spray for scale and leaf curl. Where scale is heavy, a three-percent oil emulsion should be used instead of two percent. For direction for making oil-bordeaux, see the section on spray materials. Do not apply the dormant spray at temperatures lower than 45° F. or when the temperature is falling.

Zinc sulfate and chemical hydrated lime are recommended for use in all peach sprays containing lead arsenate. Zinc-lime in the mixture reduces arsenical injury such as leaf drop. Wettable sulfur is sold in Kentucky under various trade names (see list under spray materials).

Brown rot control should not be neglected on early varieties of peaches. Early maturing varieties will, of course, need spraying or dusting at a much earlier date than Elbertas. Some growers may prefer to use sulfur dusts instead of wettable sulfur sprays for brown rot control. If a dust is used in place of the second pre-harvest spray, dusting may be delayed until a few days before harvest. Dusting may also be done during harvest if brown rot is increasing.

Mixing. Run a few gallons of water into the spray tank, then add the zinc sulfate. As the tank is being filled, add the lime (previously made into a paste) thru the strainer, then add the wettable sulfur, if required, and finally add the lead arsenate when the tank is nearly full.

Cautions. Do not apply any spray to peaches when the temperature is above 90° F. because of danger of burning. Apply lead arsenate only when trees and foliage are dry. Peaches sprayed with lead arsenate within three weeks of harvest will have residues above the tolerances set up by the federal government. Avoid using pre-harvest curculio sprays by following the system of jarring and picking up drops as recommended. Never use lime sulfur, Bordeaux mixture or dormant spray oil emulsion as summer sprays on peaches.

PEACH PESTS

Plum Curculio. The adult curculio is a grayish-brown snout beetle with rough humps and white spots on its wing covers

(figure 8). It is about one-fifth of an inch long. Adults hide thru the winter under leaves and trash in and near orchards, preferably along fence rows or in woods and plum thickets. In the spring, with the first prolonged spell of warm weather, curculios emerge from winter quarters and fly to fruit trees. Jarring records for Henderson and Lexington show that the first curculios enter peach orchards shortly before shuck fall begins. Curculios are found first on plum trees and along the edges of the orchard closest to woods or thickets. As the season advances, curculios migrate into and may become abundant over the whole orchard if not checked.

Figure 8. Plum curculio adult.

Curculios begin laying eggs on peaches soon after the shucks are off. Eggs are found first on plums. Each egg is laid in the tissue of the fruit and a half moon cut is made by the female around each egg puncture. Eggs hatch into small, white, legless grubs which make brown, winding tunnels into the small peaches or plums. Young fruits infested by curculio usually drop. Few larvæ survive from eggs laid while the pits are hardening and many of these fruits remain on the tree. About the third week in May the first full-grown curculio larvæ leave the drops and enter the soil to a depth of several inches. There they go thru the pupal stage and change to adult curculios. First-generation adults begin emerging in June and continue thru July. In 1932, at the Henderson insectary, the first adult of the first generation

emerged June 23. In 1938, at Lexington, the first adult emerged June 15.

First-generation curculio adults, after leaving the soil, fly to the peach and plum trees and feed on the fruit. Some of the new adults seek out winter quarters before long. Other curculios begin laying eggs in the large peaches and give rise to a second generation of larvæ. In Kentucky, second-generation curculio often causes heavy commercial loss of peaches. Infested fruits ripen prematurely and fall just before harvest. Second-generation curculio larvæ leave fallen fruit during late July and the first two weeks in August. Second-generation adults emerge from the soil in August, feed for a short time and then seek hibernating places.

Control. Sprays for curculio should be applied only if curculios are present in the peach orchard in sufficient number to warrant a spray (plums rarely escape curculio injury). Each grower should keep informed by "jarring" as to the exact situation in his own orchard and spray when and where "jarring" indicates the need. Such a program saves both time and money. Growers who do not jar their trees should follow the fixed spray schedule.

Jarring for Curculio. Jarring is done by spreading a bed sheet or large piece of canvas on the ground beneath a peach limb or tree. Sometimes, two pieces of cloth or canvas are used, one on each side of the tree. The limb or tree is then struck two or three moderately sharp blows with a padded mallet or the end of a piece of scantling padded with an auto tire casing. If adult curculios are present, they fall to the sheet where they may be counted for record, and destroyed. Jarring is only effective in the early morning, while it is still cold and the curculios are numb, and should not be done after 9 a. m. Jarring should be done first on plum trees since curculios appear there in numbers before they do on peach trees. In jarring peach trees, select those at the edge of the orchard near fence rows, woods, or plum trees.

If jarring shows curculios to be present in their most favored spots, it should be continued on selected trees thruout the

orchard. In this way their movement in from winter quarters can be followed and the parts of the orchard that need spraying can be determined. Jarring should begin a week before the shucks split and be repeated every two or three days during the three or four weeks following shuck fall.

Drop. Curculio causes fruit to drop during two periods. The first drop is caused by punctures made in the peaches by the overwintered beetles. The stung peaches usually reach a diameter of one-half inch or more and have a drop of gum over the injury. The second drops are caused by second-generation curculio worms which cause the fruit to ripen prematurely and fall just before harvest. Destroying infested peach drops is an excellent supplement to spraying. If the first drops are carefully picked up and destroyed, a peach crop nearly worm-free is ensured. Picking up the second drops aids in reducing brown rot as this disease frequently follows insect injury in ripening fruits. Destruction of both first and second drops reduces the number of curculios overwintering and helps protect the next year's crop.

To find out when and where drops should be picked up, each grower should cut open fallen peaches the size of a pea or larger, in parts of the orchard where curculios are found. Drops should be collected twice a week, as long as cutting shows that curculio worms are present. This period may last 2 to 4 weeks. The worms may be killed by submerging sacks of peaches in water for several days or the drops may be burned or buried. If buried, it should be at a depth of several feet.

Clean-up. During the fall and winter, places in and around the orchard where adult curculios may hibernate, such as fence rows, plum thickets, and railroad banks, should be cleaned up and the weeds and rubbish burned. These precautions aid in reducing curculio infestation the following season.

Peach-Tree Borer. One of the most serious pests of peach trees in Kentucky is the peach-tree borer. Trees of every age are attacked and it is not uncommon to find most of the trees infested within a year or two after planting. Borers injure peach trees near or below the ground level by tunneling under

the bark and more or less girdling young trees while older trees become stunted and sickly and produce a poor crop. An infested tree has roughened bark near the base of the trunk and a mixture of jelly-like gum and borer excrement will be found over the wounds.

Life Cycle. The adult peach-tree borer is a clear-winged moth which flies during the day and looks much like a wasp. In Kentucky, adults begin to appear the last of June and eggs are laid from July 1 until late September. Eggs are deposited on the trunk or limbs of peach trees, on nearby weeds and trash, or on the ground. The eggs hatch in about 10 days. One peach borer moth is said to lay an average of 400 eggs. Young borers hatch from the eggs and burrow into the bark at or near the base of the tree where they feed greedily and soon reach a considerable size. As many as 90 borers have been found in a single six- or seven-year-old tree but the usual number is two to ten. The writer has cut as many as 34 borers from a year-old tree. Large borers pass the winter in their feeding burrows while many of the smaller ones make winter cells in the bark of the tree. Borers begin feeding again in the spring and complete their growth. In early summer, full-grown borers enclose themselves in silk-like cocoons, usually at or near the ends of their old burrows. Here they go thru the pupal stage and in due time the adults emerge.

Control. Two good ways of getting rid of the peach-tree borer are now known. The better known, discovered in 1919, is by the use of paradichlorobenzene (PDB), a white, crystalline substance that looks like coarse salt and smells something like moth balls. Its vapor is deadly to the borer.

The following dates for treatment generally hold for this state: In eastern Kentucky, apply PDB during the last two weeks in September; in central Kentucky, late September to early October; and in western Kentucky, in October. Treatment is done in the fall to avoid infestation by borers hatching from eggs laid late in the season. For the PDB treatment to be effective, the soil temperature should be about 60° F. or slightly above and the soil should be comparatively dry. Injury to the trees may result if

PDB is applied during hot weather. Growers should take this into account when deciding on what days to make treatments. In Kentucky, spring treatment has not given satisfactory control. By the time the soil is warm enough to liberate the fumes of the PDB, borers will have done much injury and may be deep in their burrows.

Method. To prepare a tree for treatment, the grass and debris should be removed from around the trunk and the ground smoothed off (figure 9a). If borers are working much above ground level, draw in some fresh soil and pack it down firmly around the trunk so that the earth is approximately level with the highest borer hole. PDB should then be placed around the tree in a ring about one inch from the tree, not nearer. After

Figure 9. (a) Ground leveled and a ring of PDB crystals placed around trunk, (b) soil placed over PDB and packed with back of spade to form a cone.

this a shovelful of well-pulverized soil should be sprinkled carefully over the crystals, from above, in such a way to avoid pushing them against the bark. Several additional shovelfuls should then be placed around the tree and packed to form a cone (figure 9b). Since the vapor of PDB is heavier than air, it soon saturates the soil and tunnels and poisons the borers. With

average fall conditions, most of the PDB will evaporate in four to six weeks killing 90 to 100 percent of the borers. Cooler weather and rain hinder evaporation. The mounds around the trees must be removed five to six weeks after treatment. Trees may be injured if mounds are left over winter.

Dosage. Trees six years of age or older should receive one ounce of PDB. On four- and five-year trees and unusually large and sturdy three-year trees, ¾ ounce should be used. In Kentucky, two- and three-year-old trees have been safely treated with one-half ounce of PDB. If growers choose to apply PDB to one-year trees, the dosage should not exceed ¼ to ⅓ ounce per tree. In measuring out PDB, use a small bottle or tin box holding the right amount.

Ethylene Dichloride Treatment. Recently, federal entomologists have suggested the use of ethylene dichloride emulsion for peach-tree borer control. It has certain advantages over PDB since it is easier to apply, safer on young trees and can be used later in the fall and also in the spring. Home preparation of ethylene dichloride emulsion requires some skill. Several prepared emulsions containing 85 percent ethylene dichloride are now on the market.

Worming. The old method of killing peach tree borer was by hand worming. This usually gives a kill of about 50 percent. It is suggested for use where growers do not care to risk PDB injury to young trees. In worming, the borers are removed from the trunk with a sharp knife and wire or a special instrument.

Oriental Fruit Moth. Fruit moth is a pest of peaches which was not found in Kentucky until 1928. It is thought to be native to Japan and it was brought to this country in flowering cherries. The oriental fruit moth is present in most Kentucky orchards and in some years causes considerable damage to Elberta and later varieties of peaches.

During the first part of the season, worms of the fruit moth develop in peach twigs, causing the tips to wilt and die back (figure 10). In July, with the hardening of the twigs, fruit injury begins. There are two kinds of injury. In the first, which may be called visible injury, the worm burrows into the

peach, often near the stem, and a large mass of gum and frass marks the spot. The worm then continues to work about the stone and brown and other rots complete the destruction of the fruit. In the second type of fruit injury, the worm enters at the stem end and its entry place is not detected until the peach is opened.

Oriental fruit moths look something like codling moths but are smaller, averaging about a quarter of an inch in length (figure 10). Their color is grayish brown. Their life history

Figure 10. Oriental fruit moth and injury of larvæ to peach twigs. Twig on right split open to show burrow and larva.

is very similar to that of the codling moth except that the worms feed in twigs early in the season and there are more generations in a year. At Lexington, in 1938, there were five generations. Oriental fruit moth worms have legs, which distinguishes them from curculio worms. They can be distinguished from codling moth worms by their having a small, brownish comb-like structure on the last segment.

Control. The pre-harvest application of oil dusts has given good control in some states. This dust is composed of 35 pounds of dusting sulfur, 12½ pounds of hydrated lime and 2½ pounds

of spray oil. To be effective, the materials must be thoroly mixed; mixing in the duster is not sufficient. Either a dust-mixing machine must be used or a ready-mixed dust obtained from a reliable company. Dusting should begin about 20 days before Elberta harvest and repeated at 5-day intervals, putting on a total of three or four dusts. Oil dusts also control brown rot and may be substituted for the wettable sulfur suggested in the spray schedule.

Whether or not severe fruit-worm damage to Elberta occurs in a given year depends on the ripeness of the fruit, the hardness of the twigs and the stage of fruit-worm development. In many years injury can be avoided by picking Elbertas before the worms come. Since late varieties of peaches are most subject to fruit-worm injury and allow late broods to continue their life cycle, it is recommended that no varieties maturing later than Elberta be grown in Kentucky. Since oriental fruit moth can develop in apples and can maintain itself on apples in years when there is no peach crop, mixed plantings of apples and peaches are not advised.

The most promising line of attack on the oriental fruit moth is the use of insect parasites. Beginning in 1930, the Department of Entomology and Botany and the federal Bureau of Entomology have released thousands of parasites in many peach orchards in McCracken, Henderson, Livingston, Union, Fayette, and other counties. Many of these parasites belong to species working on oriental fruit moth in the Orient. Certain native parasites are already working on oriental fruit moth in Kentucky and at least sixteen kinds have been identified. In one Henderson orchard, in 1938, parasites killed 64 percent of the second-brood fruit moth worms.

Scale. San Jose scale affects peach much as it does apple, except that tree injury on peach is much more severe. In 1937 and 1938, scale was very abundant in many Kentucky orchards (figure 11). Under no circumstances should the dormant spray for scale be omitted in this state. For a discussion of scale and its control, see under apple pests.

Figure 11. Peach tree dying from San Jose scale.

Figure 12. Shot-hole borer injury.

Shot-hole Borer. Frequently the trunks and branches of peach trees have numerous tendrils of gum exuding from them (figure 12). This exudes from minute holes made by the adult borer as it enters to lay eggs or when the adults emerge in completing their life history. The grub-like larvæ burrow between

Figure 13. Peach-twig borer injury.

the bark and the wood. These insects also affect plum, apple, pear and other deciduous fruit trees. They work principally in weakened branches and trees which should be cut and burned. The adult beetle is brownish-black, about 1/10 of an inch in length, cylindrical and has a much reduced snout. There are three or four generations each year.

Peach Twig Borer. The larvæ of the peach twig borer tunnel in peach twigs in a manner similar to that of Oriental fruit moth larvæ (figure 13). When abundant, some degree of control may be obtained by clipping off and destroying the wilted twigs.

Green June Beetle. These destroy ripening peaches, nectarines and many other fruits and vegetables during July and August (figure 14). They are the adults of grubs which commonly breed around manure piles, straw and hay stacks or in poorly drained soil containing considerable organic matter.

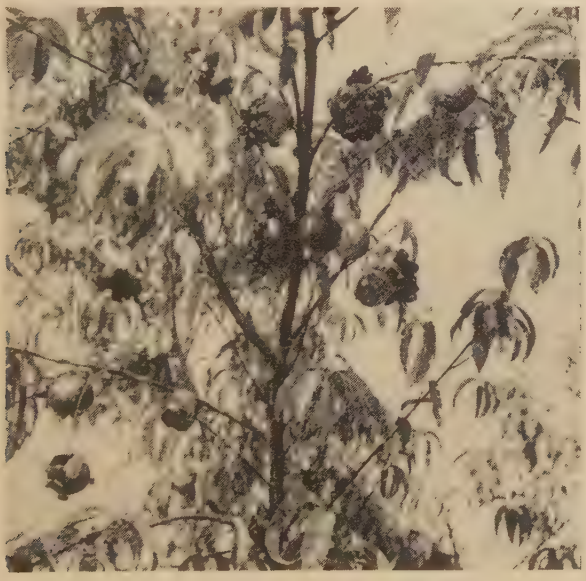

Figure 14. Green June beetles injuring nectarines.

Since the beetles are attracted by odor, old fruit should be picked as soon as possible and ripe fruit should not be left on the trees or on the ground. Removal of manure piles and haystacks from the vicinity of orchards should prove helpful.

Brown Rot. This is a fungus disease best known to the fruit grower as a rot of ripening fruit of peach, plum and cherry. It may cause blossom blight if wet weather prevails

during the blossoming period. The fungus attacks leaves and shoots affected by peach-leaf curl, where it may persist and act as a source of infection for the ripening fruit. In dry seasons brown rot may be no factor whatever but if wet weather prevails during ripening, a crop may be destroyed in the course of about three days. If much fruit is rotted and allowed to remain on the tree, fruiting wood for the following year is destroyed by the fungus penetrating the twig and killing it. This type of injury is common in Kentucky.

The fungus which causes brown rot lives thru the winter in rotted or mummied fruit in which the fungus forms large, hard masses known as sclerotia. These mummied fruits may persist on the ground for several years, unless buried, when they are likely to decay. About the blooming period of the peach, mushroomlike growths develop from the partially buried or buried mummies. From the upper surface of these bodies spores are discharged in clouds from time to time. In wet seasons these spores cause blossom blight. Blighted blossoms, infected leaf-curl lesions and perhaps other types of infection carry the fungus thru the summer and furnish spores for infection as the fruits approach the ripening stage. Peaches which ripen prematurely because of curculio injury are likely to decay and furnish an abundant source of spores for the ripening fruits. Thus, curculio control is essential to brown rot control.

Control. Brown rot may be controlled commercially with sulfur sprays or dusts. If a spray is to be used, it should be applied, preferably, about three weeks before ripening. Dusting may be delayed until the first appearance of the disease or until a few days before harvest, or may be done even during harvest if the disease is increasing. This serves also to protect the fruit during storage or shipment. Removal of all decayed fruit from the orchard at harvest time aids control in following years. If mummies are present on the ground and the orchard is to be cultivated, disking just before blooming disturbs the mummies and prevents the development of the fruiting bodies.

Peach-Leaf Curl. Peach-leaf curl is a disease of peach leaves which appears soon after the buds open in the spring and

persists until the leaves affected at that time have fallen off. In seasons when the disease is particularly severe, leaves on new shoots as far as ten inches from the position of the original bud may be affected, indicating that infection may occur long after the buds open. Affected leaves are thickened, blistered, and very much distorted. In the early stage the affected portions turn red; later they turn a waxy gray. Severely affected shoots may be attacked and killed by the brown rot fungus. On the waxy surface of affected leaves spores are produced in abundance and are carried by air currents to the twigs and branches where the fungus lives much like a yeast on the bark the remainder of summer and the next winter. A fungicide spray thoroly applied at any time during the dormant season controls the disease. Partial control may be obtained by spraying after the buds have begun to open. The only peach variety which has been observed to be highly resistant to the disease in Kentucky is Mayflower.

Peach Scab. Scab is caused by a fungus closely related to the apple-scab fungus but differing from it in that the fungus of the peach overwinters in small cankers on the young twigs, not in the dead leaves on the ground. The spores develop rapidly in wet periods and are washed from the cankers to the developing fruits. The fungus causes dark greenish to black, freckle-like spots on the upper surface of the fruit, which frequently are so numerous as to blacken this side of the fruit completely. A few scab spots are not injurious but heavy infection may result in cracking and, toward ripening time, wilting, and finally rotting of the affected side of the fruit. Infection takes place during wet periods after the young fruit is about half an inch in diameter. About eight weeks are required, following infection, before the spots become visible. Consequently, early varieties may escape with little apparent infection, even without a spray, while on later varieties, as the Elberta, only early infection must be prevented. On still later varieties, a second scab spray may be necessary about a month after the first. The disease is easily controlled by one or two sulfur sprays applied about the time the fruits are half an inch in diameter.

Bacterial Spot or Bacterium pruni Leaf and Fruit Spot. Much injury to peach foliage caused principally by sprays and low fertility of the soil has been attributed to bacterial spot. Bacterial spot, or black spot, affects fruit, leaves and twigs. The disease overwinters in infections in twigs which do not develop to any extent until spring. In the spring, after growth commences, bacteria are discharged from these cankers and infect the leaves and young fruits. The spots on the leaves are small, nearly black, and oily. The early ones are associated with twig cankers. The spots on the fruit are small, brown to black lesions, often with cracks across them. Experience in Kentucky as well as elsewhere indicates that the spot is rarely a factor in orchards growing in a fertile soil, but may cause severe injury in orchards on badly worn soils. Manuring and other forms of fertilizing tend to reduce the injury. Zinc sulfate spray has been recommended as a means of control, but its effect seems to be in preventing spray burn, rather than in control of the disease.

PLUM

For plums use the same spray schedule as for peaches. Special attention should be given to the curculio, as plum is the preferred host.

NOTES ON THE CHERRY SPRAY SCHEDULE

Cherries are less subject to attack by scale insects than most other fruits but they are not immune. The dormant spray (No. 1) should be omitted unless scale insects are present. Certain of the neutral copper fungicides show considerable promise for the control of cherry leaf spot. These are recommended for trial and should be used according to the manufacturer's directions.

PESTS OF THE CHERRY

Leafspot. This is the chief limiting factor to cherry production in Kentucky. The disease lives over winter in old leaves on the ground and the first infections appear on the new foliage early in the summer. Some of the affected leaves turn yellow and drop, and sometimes the tree may be practically defoliated. This results in a weakened condition of the tree, failure to form

CHERRY SPRAY SCHEDULE*

Spray	Time	Spray Mixture	For
1. Dormant	Before buds swell	Oil emulsion 2 percent or Liquid lime sulfur 1 to 8	Scale. Seldom necessary. Omit if scale not present
*2. Petal fall	When most of petals have fallen	Liquid lime sulfur 1 gal. or Bordeaux mixture 2-4-50 or Dry lime sulfur 4 lbs. Hydrated lime 1½ lbs. Water to make 50 gals.	Leaf spot, curculio, slugs. Omit the hydrated lime if Bordeaux is used
*3. Shuck fall	Ten days to two weeks after petal fall	Same as No. 2	Same as No. 2
4. First cover	Two weeks after shuck fall spray	Same as No. 2	Same as No. 2
*5. After harvest	Immediately after harvest	Same as No. 2	Leaf spot

* For the convenience of the home grower the most important sprays are starred.

fruit buds and susceptibility to winter injury. The fruit on weakened trees suffers in size, color and quality. Spraying is an effective control measure. In door yard plantings, raking and burning all leaves as they drop in late summer and fall, helps to keep the disease under control.

Brown Rot. Brown rot is seldom serious on sour cherries but is often destructive to sweet cherries about harvest time. Wet weather and high temperature favor rot.

Curculio. The plum curculio is also a pest of cherries. Unlike other fruits infested by curculio, infested cherries usually remain on the trees until picking time. For a discussion of curculio see section on peach pests.

Aphids. If aphids are present, spray with nicotine sulfate at the rate of ½ pint to 50 gallons of water, before the leaves curl. Use a soap spreader with the nicotine unless it is combined with one of the regular sprays.

Figure 15. Cherry slugs and early injury.

GRAPE SPRAY SCHEDULE

Spray	Time	Spray Mixture	For
1. Dormant	Dormant season	Oil emulsion 2%, or Lime sulfur 1 to 8	Grape scale or San Jose scale. Omit if no scale
*2. Delayed dormant	New growth about 1 inch long	Bordeaux 8–10–100	Black rot, mildew
3. Cluster breaking	Two weeks after No. 2 or when shoots are 4 to 8 inches	Bordeaux 8–10–100	Black rot
*4. Prebloom	When first blossoms are opening	Bordeaux 8–10–100 Spreader (see note)	Black rot
*5. Postbloom	When bloom is nearly complete	Bordeaux 8–10–100 Lead arsenate 3 lbs. Spreader (see note)	Black rot Berry-moth worm
6. First cover	Just before berries touch, or when size of pea	Bordeaux 8–10–100 Lead arsenate 3 lbs. Spreader (see note)	Black rot Berry-moth worm Root-worm beetle
7. Second cover	June 22–25 in eastern Kentucky	Nicotine sulfate 1 pt. Soap 2 lbs. Water to make 100 gals.	Leaf hoppers

Slugs. The soft-bodied, slimy larvæ which skeletonize cherry leaves are the larvæ of the pear slug (figure 15). Badly injured leaves drop and trees may be completely defoliated. When defoliation occurs, the cherries fail to mature and next year's fruit buds may fail to form. Spraying with lead arsenate easily controls slugs. The regular spray schedule takes care of them in the spring. If abundant in late summer or fall a special spray should be applied.

NOTES ON GRAPE SPRAY SCHEDULE

It is best to use a spreader, beginning with the pre-blossom spray. For 100 gallons, use 1 pint of fish oil (refined for spraying) or 1 pound of soap chips made for spraying, or one quart of liquid soap.

Altho this spray schedule is designed for the commercial grape grower, it may be varied to suit conditions found in the home vineyard. Some may desire to use only the most important sprays. These are marked with an asterisk (*). Since black rot spreads from year-old canes to the young canes early in the spring, the delayed dormant spray should not be omitted where black rot has previously caused injury. The preblossom and postblossom sprays are most effective for the protection of the fruit. Black rot cannot be controlled successfully if spraying is delayed until the rot appears on the fruit. Thoro spraying with good pressure is important.

Protection by Sacking. In the garden the clusters may be protected by sacking, in lieu of the postblossom sprays. Sacking is not only protection from diseases, insects and birds, but is a means of producing perfect clusters of fruit for home use and for exhibition. The ordinary grocer's 2-pound manila sacks are satisfactory for most varieties, or 3-pound sacks for exceptionally large clusters.

PESTS OF THE GRAPE

Black Rot. This is the most serious disease of grapes in Kentucky. It is carried over from year to year on the old canes and is spread to the young shoots and leaves when growth starts in the spring. Infections on new canes a few inches long,

appear to carry the fungus over to the following year. These should be prevented by an early spray. Infection of the fruit stems, even before bloom, may result in loose clusters. The first conspicuous appearance of rot is on the half-grown grapes, as small, black or brownish spots that enlarge rapidly. Finally the berry becomes shriveled and mummified. Since infection takes place several weeks before it can be observed on the fruit, sprays to be effective must be applied early. Dry weather during the spring, when the spores are ordinarily spread, may prevent infection and this explains why there is little damage some years.

Berry Moth. This moth lays its eggs on the blossoms and a later generation lays eggs on the berries in midsummer. The first-generation larvæ feed on the blossoms and small berries. The berries in the cluster usually are webbed together. The second-generation larvæ feed on the inside of the berries. The berries develop purple spots, which may crack and rot. For this reason, the injury may be confused with black rot. Lead arsenate as recommended in the spray schedule usually is effective in control.

Grape Flea Beetle. In an occasional year the grape flea beetle, a glossy, greenish-blue insect somewhat under ¼ inch long, appears in destructive numbers upon the grape buds, eating the centers out of them. One and a half pounds of lead arsenate should be added to each 50 gallons of the delayed dormant spray, or cluster-breaking spray, if grape flea beetles appear.

Grape Leaf-Folder. The name is descriptive of the habits of the larvæ of this little black moth. The larvæ fold the leaves upward and skeletonize them by feeding on the inside of the folds. Lead arsenate used in the spray is effective. In home plantings where the grape leaf-folder is commonly found, hand picking of the folded leaves is recommended. Supplemental winter clean-up measures aid in its control.

Green June Beetle. This is a very annoying pest that attacks the ripe fruit and destroys the clusters. As the fruit is ripe at the time of the attack, arsenical sprays cannot be used. If the beetle is troublesome, the fruit should be picked as soon

as ripe. Sometimes it is practicable to jar these clumsy beetles from the fruit into a pan of water and kerosene. Usually jarring must be repeated daily for several days. An excellent method of preventing damage from green June beetle in the home vineyard is to sack the fruit.

Leafhoppers. Several species of leafhoppers attack the grape in Kentucky. All are minute, triangular-shaped insects which pierce the tissues of the leaves and suck the cell sap. When disturbed they fly in swarms. This is particularly noticeable in late July if an earlier spray has not been applied. The first evidence of leafhopper injury is small, whitish or yellowish spots on the leaves. In severe attacks the leaves become yellowish or brown and may fall. Leaf injury interferes with the proper ripening of the grapes and reduces the sugar content. The growth and vigor of the vines are reduced.

To control grape leafhoppers, use 1 pint of 40 percent nicotine sulfate solution with four pints of a liquid soap spreader such as cocoanut oil soap (40%) or two pounds of hard-soap spreader made for spraying, in 100 gallons of water. For 3 gallons use ½ ounce of the nicotine sulfate with 2 ounces of liquid soap or 1 ounce of a hard-soap spreader. Since the young insects (nymphs) do not develop wings until mature, spraying is most effective just before the oldest of the first brood develop wings. This period in central and eastern Kentucky is reached about June 22 to 25. In western Kentucky it frequently occurs a few days earlier. The young insects of the second generation begin to develop wings late in July. If the June spray was not effective or was omitted, a spray for the second-generation nymphs late in July may be necessary.

Commercial rotenone and rotenone combination sprays are also very effective. Tests in 1933 and 1934 at the Experiment Station, showed their effectiveness was about equal to that of nicotine-soap combinations but the cost greater. The rotenone sprays used contained a spreader of soluble pine oil and were pleasant to use. They should be used as recommended by the manufacturer, as different brands have different rotenone and spreader content.

Rootworm. The adult is a beetle which feeds on the foliage and its work may be recognized by the chain-like marks on the leaves that result from its habit of feeding. The larvæ feed on the roots, devouring the smaller ones and stripping the bark and eating out pits and furrows in the larger ones. The vines become stunted or may be killed. Since the adults feed on the leaves control consists in spraying with lead arsenate.

Scale. Grape canes may be attacked by two species of scale, the grape scale and the cottony maple scale. Both can be controlled by dormant spraying. Spraying is not recommended unless scale is present.

Grapevine Root Borer. This is the larva of a clear-winged moth which might be easily mistaken for a large wasp. The larvæ stunt grapevines by tunneling along and thru the underground stem and roots (figure 16). Borers are often found in roots two and three feet out from the base of the vine. In eastern Kentucky, vineyards are frequently seriously stunted by this pest and produce little fruit and that of poor quality. No chemical treatment is known for destroying grapevine root borers. It is suggested that heavily infested vineyards be destroyed and new vineyards located as far away from old vines as possible.

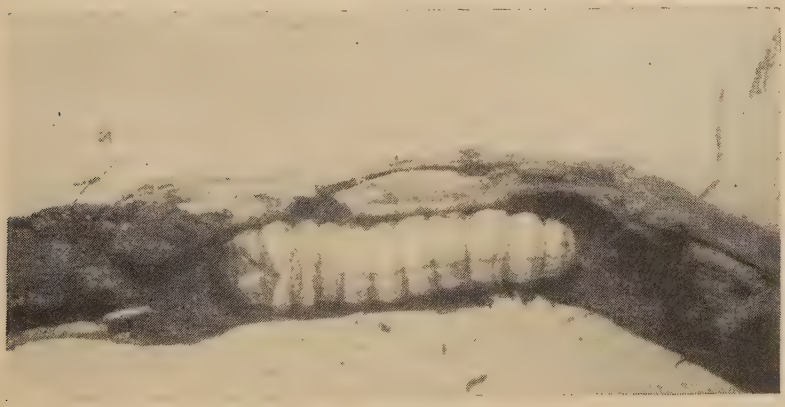

Figure 16. Grapevine root borer.

PESTS OF THE STRAWBERRY

Crown Borer. This insect has been a serious pest of strawberries in western Kentucky for the past forty years. Some counties no longer grow berries simply because crown borer made it unprofitable. Other counties will have this same experience if measures are not taken soon to reduce the crown borer infestation.

Figure 17. Crown borer injuring berry plant.

Grubs of the crown borer injure strawberry plants by tunneling thru the crowns (figure 17). This kills or stunts plants or reduces the number of runner plants. Injury is most severe in dry years. As a result of crown borer attack, the first crop in heavily infested patches is small, because of the poor stand of plants. By the second year the crop usually is not worth the cost of picking.

The adult crown borer is a brownish snout beetle with three black bars on each wing cover (figure 18). In shape and size it resembles a large grape seed. Adults overwinter under trash or in the soil in infested berry patches. In February they feed on strawberry leaves from the undersides and early in March the first eggs are laid. The egg-laying period extends thru August. Crown-borer eggs are usually deposited in holes made in the berry plants just above the first lateral roots and are well covered

with dirt and bits of tissue. Crown-borer grubs begin tunneling in berry plants in April but their damage is not noticeable before June. Pupation takes place in the burrows made by the grubs in the crowns. Adult crown borers begin emerging late in June and continue to emerge over a period of at least four months. In 1937, at Princeton, evidence of a small second generation was found.

Figure 18. Adult strawberry crown borer.

CONTROL.

1. Plow under all berry patches as soon as the second crop is harvested.

2. Where practical, destroy common cinquefoil (five-finger) and wild strawberries by digging and burning. Crown borer breeds in these two plants in western Kentucky.

3. Set new berry patches at least 350 yards from other berry patches or cinquefoil. If this distance is not practical, then set as far away as possible.

4. Use only young, borer-free plants for starting new plantings. Plants from patches inspected for crown borer and passed by the state nursery inspector are much preferred.* Plants from infested patches may be freed of crown borer if they are dug before March 1 and properly cleaned. All plants should be dug between December 1 and March 1. After digging, remove all dirt, trash, and dead and spotted leaves, then wash plants in

* Write W. A. Price, State Entomologist, Experiment Station, Lexington, Ky., for a list of growers who can supply certified plants.

a pond or barrel of water to free them of crown-borer beetles. Plant at once or heel-in at a distance of 350 yards from a source of infestation.

5. Always plant on land that has been in legumes or in cultivation for several years previously.

Leaf Roller. The light green worm of the strawberry leaf roller feeds on the surface of the leaves for a short time after hatching, then folds the two halves of a leaflet together and feeds on the protected surface inside until it becomes full grown. Pupation occurs inside the folded leaflet and the leaf roller moth soon emerges to lay eggs for another generation. In Kentucky, there are three or four generations a year. The amount of leaf-roller injury varies greatly from year to year. Good control is obtained by mowing and burning the berry fields immediately after harvest.

White Grub. The U shaped white grubs which kill strawberry plants by biting off the large roots and eating into the crowns are the larvæ of several species of brown May beetles

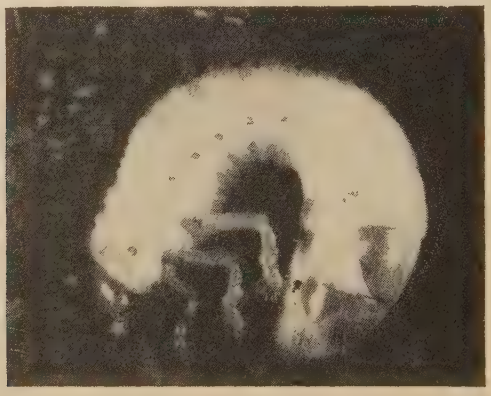

Figure 19. White grub.

(Phyllophaga) (figures 19 and 20). The white grubs injuring berry plants in eastern Kentucky belong to entirely different species from those injuring plants in western Kentucky. The eastern Kentucky species require two or three years for their

development while one of the most common white grubs damaging plants in western Kentucky has an entirely different life cycle lasting two years. In the state as a whole, grubs are most destructive the second summer in their life cycle. The May beetle grubs attacking strawberries should not be confused with the grub of the green June beetle which crawls on its back and feeds largely on dead organic matter in the soil.

CONTROL. Set berries on land which has been in tobacco or some other cultivated crop for the two previous years; never on sod land. If possible, avoid planting berries close to the food trees of the adult May beetles. Favorite food trees of the species

Figure 20. White grub injury to strawberry plants

attacking strawberries in western Kentucky are the red oak, willow oak, persimmon and elm. When plants first wilt down from grub attack, dig out the grubs and kill them to prevent migration to other plants in the row.

Leafspot. Leafspot is not a serious pest on the two leading varieties, Aroma and Premier. The Blakemore is more susceptible. Leafspot may be held in check on the resistant varieties by removal of all affected leaves when new plantings are made, and by mowing and burning the planting immediately after harvest. If these methods are not effective on susceptible varieties, spraying with 3–4–50 Bordeaux mixture may be necessary. Sprays as follows are recommended: (1) As soon as growth is well started in the spring; (2) repeat as often as necessary to keep the foliage well covered until the fruit is two-thirds grown; (3) one or two additional applications in late summer.

RASPBERRY

Leafspot. From a limited experience with Latham red raspberries, it appears that leafspot is the injurious disease of this variety in Kentucky. Leafspot also affects black raspberries but does not cause extensive defoliation. Leafspot appears on Latham and Chief raspberries when the new canes are about 10 inches high and new infections occur after every rain. A group of leaves may become old enough, between rains, to be highly resistant, while the young, tender leaves immediately above them may be blackened and dried up by leafspot. By late summer new canes often are defoliated except for a few leaves at the tips. If new canes are tied to a stake, they may appear to have good foliage but when the strings are cut and the canes separated they may be found to be severely defoliated. It appears that extensive defoliation leaves the canes in condition so that the buds which develop the fruit spurs, and sometimes the entire canes, are killed during the winter. Raspberries growing in highly fertile soil are much less subject to winter killing following leafspot attack than those on less fertile soil.

Control. Leafspot quickly enters new plantings, even those set entirely with plants from which the tops have been removed at digging time, unless the new planting is isolated from native brambles, when it may remain free from spot. The fungus evidently is carried by air currents from overwintering fruiting bodies on leaves of wild brambles. The fungus also overwinters

on the canes; therefore these should be removed as soon as picking is finished. Spraying with 3–4–50 or 4–4–50 Bordeaux mixture, to which is added ½ pound of soap flakes or chips, or 1 pint of 40 percent liquid cocoanut oil soap (1), when berries are half grown, (2), immediately after harvest and removal of old canes, (3), three weeks after harvest, and (4), six weeks after harvest, has greatly reduced defoliation and has largely prevented winter injury.

Anthracnose. This disease of black raspberries occurs on the one- and two-year-old canes, causing grayish spots with purplish borders, ⅛ inch or more in diameter. The older lesions extend into the sap-conducting tissue. The numerous cankers of the canes partly girdle them, resulting in small, shriveled fruits which sometimes dry before ripening. The fungus overwinters on canes from which it is spread to the new shoots by washing rains. The fungus causes superficial spots on Latham raspberries, but there is no evidence that it causes extensive injury.

Treatment. New plantings of both reds and blacks should be set with clean stock or plants from which all above-ground parts have been removed before the plants are taken to the field. Black raspberries should be planted when dormant, for if new shoots have appeared above ground at digging time, infection of leaves and stems may already have taken place. Old fruit canes should be removed immediately after harvest and severely infected new canes may be removed at the same time. Freedom from weeds is essential to good control.

For black raspberries and blackberries a delayed dormant spray of liquid lime sulfur, 1 to 10, or Bordeaux mixture, 4–4–50 (with calcium caseinate 1 pound to 100 gallons, as a sticker, or with one of the soap spreaders) applied when the leaves first begin to show green, is effective most years. In wet seasons and in severe infestations, a second spray of Bordeaux, 4–4–50, applied not later than a week before the blossoms open, may be necessary.

Red Spider. The raspberry foliage is often attacked by red spider mite, especially in wet seasons. Tests show that this

pest can be controlled with two applications of one percent summer oil, spaced a week apart. Growers are cautioned that the application of any sulfur compound, no matter how mild, causes severe leaf drop on raspberries.

CURRENT AND GOOSEBERRY SPRAY SCHEDULE

Time	Spray Mixture	For
Dormant	Oil emulsion 2% or Lime sulfur 1 to 8	Scale when present
Two weeks after full leaf	3–4–50 Bordeaux mixture Lead arsenate 1 lb.	Leafspot Sawfly worms
After harvest	3–4–50 Bordeaux mixture	Leafspot

SPRAY MATERIALS

Lead Arsenate. Acid lead arsenate is the standard arsenical insecticide now used by fruit growers. It is sold in the form of a light, fluffy, pink powder. The natural color is white but coloring has been added since 1938, by agreement of the manufacturers, in the interest of safety for the consumer. Lead arsenate is extremely poisonous not only to insects but to man and animals and great care should be used in handling and storage.

Many chewing insects are killed by lead arsenate spray. Those of importance to the fruit grower are codling-moth worms, curculio, and berry moth. Lead arsenate is commonly used at the rate of one to two pounds to fifty gallons of water. "Chemical" hydrated lime equal to, or sometimes twice the amount of, the lead arsenate is added to prevent burning tender foliage.

Lead arsenate may be added safely to Bordeaux mixture, liquid lime sulfur, dry lime sulfur, wettable sulfur, oil emulsion, or nicotine sulfate. When applied to peaches, zinc sulfate and lime should always be combined in the spray to prevent foliage injury. In making up a spray in the tank always add the lead arsenate last, when the tank is nearly full. To prevent clogging nozzles, make a thin paste of the lead arsenate and water, in a bucket, and pour it thru a screen into the spray tank. Since lead arsenate goes into suspension and not solution when added to water, good agitation is necessary to keep the spray thoroly mixed and prevent settling.

Other Arsenicals. Calcium arsenate, magnesium arsenate, manganese arsenate, zinc arsenate and Paris green are sometimes offered as substitutes for lead arsenate. None of these materials are recommended for use by Kentucky fruit growers. If used they may cause inferior control or severe plant injury. Certain of these materials, however, are valuable insecticides for use on other crops such as vegetables, cotton, and tobacco.

Fluorine Compounds. The use of cryolite, barium fluosilicate and other fluorine compounds as substitutes for lead arsenate to control fruit pests has proved unsatisfactory in Kentucky and is not recommended.

Spray Residue on Fruit. The U. S. Department of Agriculture has established tolerances for lead, arsenic and fluorine on fruits sold out of the state. According to the 1938 ruling, interstate shipments of fruits carrying more than .01 grain of arsenic trioxide or more than .025 grain of lead per pound of fruit are subject to seizure. The tolerance for fluorine is .02 grain per pound of fruit.

Apple growers who face serious codling-moth problems can meet tolerance requirements by (1) concentrating their spraying efforts on the first brood; (2) shifting to oil-nicotine or fixed nicotine sprays during second-brood worm attack, or (3) removing residue by washing. Where fruit bears residues slightly over tolerance, wiping may bring it under tolerance. Dilute hydrochloric acid is commonly used as a washing agent in this state to remove excessive lead and arsenic residues.

Zinc Sulfate. Zinc sulfate, or white vitriol as it is sometimes called, is commonly sold in the crystal and the mono-hydrate form. Five pounds of the mono-hydrate form is equal to 7½ pounds of the crystal. Zinc sulfate and lime are used in peach sprays to reduce the injurious effect of lead arsenate on peach foliage. To prepare zinc-lime spray, fill the spray tank half full of water and with the agitator running slowly pour in the zinc sulfate. Make a thin paste of the lime and as the tank is filling up wash it thru the strainer. After the zinc-lime com-

bination is thoroly mixed add the wettable sulfur and the lead arsenate. Apply at once.

Lime. Lime for spraying should be "chemical" hydrated lime. Other hydrated limes may contain impurities which injure fruit, foliage or spraying equipment.

Lime Sulfur. Concentrated, liquid lime sulfur is manufactured and sold by many commercial firms. It can be used during the dormant season as a control for scale insects and for peach leaf curl. The correct dilution for dormant season application is one part of liquid lime sulfur to 8 parts of water. This is equivalent to 11 gallons of lime sulfur diluted with enough water to make 100 gallons. As a fungicide for preblossom scab sprays on apples, the standard dilution is 1 to 40, which approximates 2½ gallons of lime sulfur diluted with water to make 100 gallons. The present tendency is to use as little lime sulfur as possible in cover sprays on apple. One to 50, one to 60, and one to 100 are common dilutions.

Dry lime sulfur is a commercial product made by drying liquid lime sulfur. Home growers often find this a convenient material to use in place of liquid lime sulfur or oil emulsion. As a dormant spray at least 30 pounds of dry lime sulfur should be used to 100 gallons of water. As a summer spray use four pounds of dry lime sulfur in place of each gallon of liquid lime sulfur.

Wettable Sulfurs. These are commercial products in which sulfur has been combined with some wetting agent such as lime and casein, starch or glue, to form compounds which mix readily with water. Altho these materials were developed primarily for use on peach trees, they are being used more and more on apple in the postblossom sprays for scab control. Since the wettable sulfurs are inferior to liquid lime sulfur for controlling scab, they are best used where scab has been well controlled in the preblossom sprays.

Wettable sulfurs are sold in Kentucky under various trade names some of which are Microcide, Mulsoid, Electric Spray, Mike, Dritomic, Magnetic, Mist Brand, Sulfuron, Sulfocide, and Catalytic. Any superiority of one material over another usually

depends on the quality and fineness of the sulfur used. Such materials should be used according to the manufacturer's directions.

Other Sulfur Compounds. Flotation sulfur and fused bentonite-sulfur are two other mild sulfur spray materials. Flotation sulfur is a by-product of the manufacture of artificial gas. The particles are very fine and form an extremely fine suspension in water. Bentonite-sulfur also forms an extremely fine suspension in water and has excellent sticking and spreading properties. These two materials may be used on peach or apple. They are said to be superior to the wettable sulfurs for apple scab control in the postblossom period.

Bordeaux Mixture. This is produced when copper sulfate (bluestone) solution and a suspension of lime are mixed together. The resulting spray is especially valuable as a dormant spray on peaches for leaf curl and a summer spray on apples for bitter rot.

The old method of making Bordeaux mixture was a slow process. It involved the slow dissolving of the bluestone crystals and the slaking of lime. Both materials were diluted in large tanks before mixing. By the instant method, Bordeaux is easily and quickly prepared.

To make instant Bordeaux:

1. Fill spray tank one-fourth full of water.
2. With agitator running wash powdered copper sulfate thru strainer.
3. Continue filling tank until two-thirds full.
4. Make a paste of chemical hydrated lime and pour or wash thru screen into tank.
5. Fill tank and apply as soon as possible.

Strengths of Bordeaux are given as 6–6–100 or 8–10–100. The first figure is the number of pounds of bluestone; the second, the pounds of lime; and the third, the gallons of water. If poison is to be added to the Bordeaux, add it last to the spray tank. CAUTION.—To avoid russet and burn, never use Bordeaux on

apples less than 14 days after petal fall, except the weak solution in full bloom. Never use Bordeaux on peaches during the growing season.

Other Copper Fungicides. Certain neutral copper compounds have been developed recently which are being tested by many stations to determine their value as controls for scab, blotch, and bitter rot of apple and for cherry leaf spot. If the grower uses these materials he should follow the manufacturer's directions as to dosage.

Nicotine. This by-product of the tobacco industry is commonly used as a contact insecticide for plant lice, thrips, young leafhoppers, and other soft-bodied insects. It is sold usually as a water solution of nicotine sulfate containing 40 percent of nicotine. The usual dilution ranges from ½ to one pint of this solution to 100 gallons of spray.

Since nicotine sulfate contains no spreading agent, it must be combined with some spreader to enable the liquid to spread evenly on the foliage and insects without forming scattered droplets. A spreader may not be necessary in power equipment where the nicotine is combined with other spray materials. A spreader is always necessary with low-power or hand equipment. Soap is a good spreader where nicotine is used alone. Four pounds of soap flakes is the correct amount for 100 gallons of nicotine spray. Soap should not be used with lime sulfur and nicotine but calcium caseinate is safe.

Fixed Nicotine. Combinations of free nicotine with bentonite clay, bentonite-sulfur or tannic acid have been developed in recent years in an attempt to find a non-arsenical material for controlling codling moth worms. Certain of these materials are now on the market and are giving control equal to or better than that given by lead arsenate. The cost of using fixed nicotine in the apple spray schedule is high. However, much of the difference in cost is offset by the fact that the fixed nicotines kill leafhopper nymphs and aphis, leave no residue requiring removal, and do not injure foliage.

Fixed nicotine is sold in the form of a fine powder which goes into suspension readily when added to water. The manu-

facturers recommend that summer oil be combined with the nicotine, beginning with the third cover spray. This combination forms a fine coating on the foliage and fruit, which clings to any codling-moth worm that crawls over it.

Fixed nicotine may be used to advantage on early varieties of apples. Lime, lime-sulfur and Bordeaux mixture should not be used with fixed nicotines since fixed nicotine requires a neutral spray mixture. Wettable sulfurs can be used for scab control in the postblossom sprays.

Nicotine and Summer Oil Emulsion. Special spray emulsions containing so-called summer oils are on the market. Summer oil emulsion combined with nicotine sulfate can be used as a substitute for lead arsenate in codling moth control. Its cost is high, however, and fixed nicotine has largely taken its place. CAUTION.—Do not use summer oil emulsion with sulfur compounds or sooner than two weeks after a sulfur application.

Spreaders and Adhesives. A spreader is a substance added to a spray solution to make the spray spread out on the surface of fruit, leaf, stem or insect, instead of standing in drops. An adhesive is a material which enables the spray to stick to the fruit, leaf or stem and prevents it from being washed off by rain. Some materials are either spreaders or adhesives; other materials serve both purposes.

In areas where codling moth is a serious problem it may be necessary to add an adhesive and spreader to the lead arsenate sprays in order to build up a heavy deposit of lead arsenate. Materials commonly used are soybean flour, calcium caseinate, neutral soap spreaders, summer oil, soluble fish oil and pine tar soap. The last three named materials are not compatible with lime sulfur and should not be used sooner than 14 days after an application of lime sulfur or severe foliage injury may result.

In some years apple foliage is susceptible to arsenical injury and the addition of any adhesive which increases the spray load is likely to increase the foliage injury. Growers are also cautioned that the use of adhesives makes removal of residue more difficult. The correct amount of adhesive and spreader may vary from orchard to orchard, depending upon the hardness of the

spray water used. Too much spreader produces excessive runoff and is worse than using none at all.

For spraying grapes, raw linseed oil, fish oil (made for spraying), or soap are satisfactory spreaders. The oils should be used at the rate of one pint to 100 gallons. One pound of hard spray soap containing 80 to 95 percent of anhydrous soap, or 2 pounds of liquid soap containing 35 to 40 percent of anhydrous soap, should be used per 100 gallons.

Tank-Mixed Oil Emulsions. Tank-mixed 2 percent oil emulsions, as used in Kentucky, cost about 40 cents for 100 gallons and are highly satisfactory as dormant sprays.

Specifications for lubricating oil for spraying are viscosity between 125 and 200 seconds, Saybolt, at 100 degrees Fahrenheit; volatility less than 2 percent in four hours at 105 degrees Centigrade. These oils are sold by oil companies at their bulk stations under such names as "agricultural spray oil", "orchard spray oil", "scale oil", etc., at about 15 to 20 cents per gallon.

FORMULAS FOR APPLES

For 50 gallons (hand pump)		For 100 gallons (power pump)	
Oil	1 gal.	Oil	2 gals.
Calcium caseinate	5 ounces	Calcium caseinate	6 ounces
Water to make	50 gallons	Water to make	100 gallons

To mix 50 gallons of solution for apples (barrel sprayer):

1. Mix 5 ounces of calcium caseinate in a 2 or 3 gallon bucket with ½ pint of water, making a thick paste. Gradually dilute until the bucket is full. This step is important.

2. Put the calcium caseinate mixture into the spray tank and add sufficient water to operate pump—usually 2 or 3 gallons.

3. Start pumping and allow the discharge from the open spray rod to flow back into the tank under full pressure.

4. Add 1 gallon of oil (continuing agitation) and pump for a few minutes; then fill the tank with water. Apply the spray immediately.

Power spray pumps are more satisfactory than hand pumps for making tank-mixed emulsions. The procedure is the same,

but in mixing with the power pump, less calcium caseinate is required.

FORMULAS FOR PEACHES

The spray mixture is the same as for apples, except that 6–6–100 Bordeaux Mixture is added instead of water, after the oil is emulsified. The experienced commercial peach grower may omit the calcium caseinate by emulsifying the mineral oil in a concentrated Bordeaux mixture made of 2 pounds of bluestone, 5 pounds of chemical hydrated lime, and about 7 gallons of water; then, while filling the tank, add 4 pounds of bluestone and 1 pound of hydrated lime to 100 gallons, making 6–6–100 Bordeaux.

To mix 50 gallons of solution for peaches (barrel sprayer), emulsify the oil with calcuim caseinate as for apples, fill the tank 2/3 full and, while pumping, add 3 pounds of chemical hydrated lime with water and 3 pounds of copper sulfate dissolved, previously mixed in water. Fill the tank with water. Apply the spray immediately.

Commercial Oil Emulsions and Miscible Oils. Prepared oil emulsions and miscible oils are sold under trade names. While these products are more expensive than the homemade, tank-mixed oil emulsion, they can often be used to good advantage, especially by the small grower. Commercial oils and oil emulsion should be used and diluted as recommended by the manufacturer.

Coal-Tar Oil Spray. It has been shown by a number of investigators in recent years that rosy aphis can be controlled by the use of a coal-tar oil spray applied during the dormant season. Tar oil controls aphis by killing the eggs. Several brands of tar sprays are now on the market, most of which also include petroleum oil emulsion for the control of scale. When properly diluted, a combination spray for aphis and scale should contain 2½ percent coal-tar oil and 2–3 percent petroleum oil.

Other Spray Materials. A material called dinitrocyclohexylphenol (DNOCHP) combined with petroleum oil has been developed recently for use as a dormant spray. It is claimed that the combination controls both San Jose scale and rosy aphis.

Cresylic acid added to petroleum oil emulsion is often recommended for the control of rosy aphis. It should be applied in the delayed dormant period.

Preparation of Sprays. Often, the grower needs a smaller or greater amount of finished spray than is called for in the spray schedules. To aid in making such quantities, a table has been prepared giving the amounts of spray materials needed for some of the common sprays when 1, 3 or 50 gallons is required (Table 1). Dry materials like lead arsenate and hydrated lime may be either weighed or measured when used in small amounts. The dosages in the table are given both ways. Each material should be weighed or measured carefully. No solid material should be poured directly into the spray tank. To avoid clogged nozzles, wash all solid materials thru a screen or cloth into the tank. Sometimes it pays to make a paste first. It is usually best to add lead arsenate last to a spray mixture. Since many spray materials form suspensions in water and do not go into solution, continuous agitation of every spray is desirable. When small sprayers are used that have no agitators, frequent stirring of the spray or shaking of the spray container is advisable. Always apply a spray as soon as possible after it is prepared. It is especially dangerous to use oil emulsions that have been allowed to stand in the tank.

TABLE 1. DILUTION TABLE FOR SOME COMMONLY USED SPRAY MATERIALS, TO MAKE ONE, THREE OR FIFTY GALLONS OF SPRAY.

Tbsp. stands for level tablespoonful; Tsp. for level teaspoonful.

Spray	For	Materials	Quantity of Material to Make		
			One Gallon	Three Gallons	50 Gallons
2% oil emulsion	Scale, leaf curl	Spray oil Calcium caseinate Water to make	⅓ cup 1 tsp. or 1/10 oz. 1 gallon	1 cup Tbsp. or ⅓ oz. 3 gallons	1 gallon 5 oz. 50 gallons
3% oil emulsion	Scale, leaf curl	Spray oil Calcium caseinate Water to make	½ cup ½ tbsp. or ⅙ oz. 1 gallon	1½ cups 1½ tbsp. or ½ oz. 3 gallons	1½ gallons 7 oz. 50 gallons
Liquid lime sulfur 1–8	Scale, leaf curl	Liquid lime sulfur Water to make	9/10 pint 1 gallon	1⅓ quarts 3 gallons	5½ gallons 50 gallons
Dry lime sulfur 3–10	Scale, leaf curl	Dry lime sulfur Water to make	¾ cup or 5 oz. 1 gallon	2¼ cups or 14½ oz. 3 gallons	15 pounds 50 gallons
Lead arsenate 4–100	Codling moth	Lead arsenate Hydrated lime Water to make	3 tbsp. or ⅔ oz. 2+ tbsp. or ⅔ oz. 1 gallon	9 tbsp. or 2 oz. 6½ tbsp. or 2 oz. 3 gallons	2 pounds 2 pounds 50 gallons
Lead arsenate 3–100	Curculio (on peach)	Lead arsenate Zinc sulfate Hydrated lime Water to make	2+ tbsp. or ½ oz. ½ tbsp. or ⅓ oz. 1½ tbsp. or ½ oz. 1 gallon	6½ tbsp. or 1½ oz. 3 tbsp. or 1 oz. 5 tbsp. or 1½ oz. 3 gallons	1½ pounds 1 pound 1½ pounds 50 gallons
Nicotine sulfate 1–800	Plant lice, leafhoppers	40% nicotine sulfate Liquid pine tar soap or liquid soap or Soap flakes Water to make	1 tsp. 1 tbsp. or ½ oz. 4 tsp. or ⅔ oz. ⅔ oz. 1 gallon	1 tbsp. 3 tbsp. or 1½ oz. 4 tbsp. or 2 oz. 2 oz. 3 gallons	½ pint 1 quart 2 pounds 2 pounds 50 gallons
Bordeaux 6–6–100	Blotch, bitter rot, leaf spot	Bluestone (powdered) Hydrated lime Water to make	2 tbsp. or 1 oz. 3 tbsp. or 1 oz. 1 gallon	6 tbsp. or 3 oz. 10 tbsp. or 3 oz. 3 gallons	3 pounds 3 pounds 50 gallons
Wettable sulfur 6–100	Brown rot	Wettable sulfur Water to make	2½ tbsp. or 1 oz. 1 gallon	8 tbsp., ½ cup or 3 oz. 3 gallons	3 pounds 50 gallons